TOP SECRET "U" TICOM/I-43

REPORT WRITTEN BY VIERLING ON

a) Synchronising Device for Teleprinters (GLEICHLAUF)

b) Artificial Speech Apparatus

c) "Three-fold wobbling" process

d) Synchronising installation for producing the "wobble-frequencies"

e) Voice-Scrambling Apparatus (small BAUSTEIN)

TICOM
20 July 1945

Copy No. 16
No. of pages 15

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The development of the Synchronising Device.

I. The problem:

The problem submitted was as follows:
In long-distance telegraphic traffic using automatic letter by letter synchronised cypher machines, special difficulties in working are encountered as the result of interference impulses in the lines of communication (L/T and especially W/T) frequently causing the cypher machines to slip out of synchronisation between the transmitting stations and the receiving stations. As the re-setting of a cypher machine always takes a certain amount of time, valuable time is lost as a result of these interruptions. An apparatus is therefore to be evolved which will prevent the de-synchronisation of the cypher machines and is especially suitable for use in connection with W/T.

The solution:

The exact synchronisation of the receiving cypher machine with the transmitting cypher machine is achieved by keeping the transmitting and receiving cypher machines synchronised by providing each with its own quartz-crystal controlled drive. When traffic commences, both cypher machines are started by an impulse given by the transmitting side.

II. Method of working:

1.) The transmitting station asks the receiving station by morse transmitting key whether it is prepared to receive.
2.) The cypher machines are then set in the prescribed starting position.
3.) When the receiving station has everything prepared for working, the receiving station asks the transmitting station to transmit the "synchronising signal".
4.) The transmitting station actuates the "synchronising signal" and control impulses are transmitted.
5.) The receiving station brings its machine into the correct phase position with the transmitting machine.
   (a) Coarse adjustment: The receiving mechanism is brought into the correct phase position by means of a press-button control. Lagging behind or straggling ahead are indicated by respective glow-lamps, which fade out when the correct phase position is reached.
   (b) Fine adjustment: By means of the same press-button control, an ammeter with its zero in the centre is set to "zero". The same phase for the control waves between the transmitting station and the receiving station is thus achieved and a start can now be made.
6.) The receiving station now asks the transmitting station by means of the morse transmitting key: "Please send the 'advance signal'."
7.) The transmitting station actuates the "advance signal" switch and, after the third of such signals, which are indicated by the lighting up of a glow-lamp, puts the starting switch over.
8.) After the third lighting up of the "advance signal" lamp, the receiving station likewise puts its starting switch over.
9.) When the starting switch is put into operation at the transmitting station and at the receiving station, the transmitting and receiving cypher machines are started synchronously by means of the transmitting mechanism at the transmitting station and the receiving mechanism at the receiving station, which are already running synchronously. The line is thus ready for working in one direction. To achieve a synchronised start in the other direction of traffic.

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III. Description of the construction of the Synchronised Teleprinter Installation.

A.) Transmitter. (Fig. 1)

Synchronisation between transmitter and receiver demands that the teleprinter signals transmitted should stand in correct relationship to the current impulses fixed by the synchronisation. On the other hand, it must at any time be possible to transmit by hand on the transmitting teleprinter, series of letters, figures or signals strung together at will. This requirement is satisfied by using a double collector, which is loaded by the teleprinter impulses coming from the teleprinter (FM) or the automatic transmitter (AS) and whose triggering is controlled by the transmitter distributor (SK) by means of synchronised cams.

In principle, the following may be said in connection with the triggering of any given teleprinter message:

If the signal is synchronised with the "SK", it can be triggered straight away. If it lags behind in point of view of time, it must be stored up until "SK" reaches its starting point again and undertakes the triggering. Care must be taken that no further signal enters the apparatus while the stored signal is being triggered. The introduction of a double collector is therefore unavoidable. This double collector consists of two sets of five telegraphic relays.

Through the start-stop distributor (PK), 10 msec are sorted out from the individual current steps of the teleprinter signals transmitted and fed alternately to collectors 1 and 2. The "PK" shaft is driven on the start-stop principle via a friction clutch. The preparation for and the commencement of the triggering of the collector relays are effected by "PK" and "SK". As soon as the first signal impulse is stored up in the collector, the triggering of the collector is prepared in "U". "SK" can then trigger the collector synchronously and pass the signals into the cypher machine, whence they are transmitted encyphered.

B.) Receiver. (Fig. 2)

The receiver picks up the incoming signals and starts the "PK" system, which is driven through a friction clutch and distributes the incoming teleprinter impulses to the collector "A".

The synchronised distributor "SK" passes the stored impulses from the collector synchronously to the cypher machine, where they are decyphered and collected in the additional collector of the receiver.

The additional collector of the receiver: if the transmitting teleprinter (FM_S) is at "stop", the transmitter sends cypher text. On decyphering, five blank signals result. The receiving teleprinter (FM_E) would not, however, remain at "stop" like the transmitting "FM_S", but would be constantly started and stopped without, however, recording any signals; the impression is given that the machine is running continuously. The "FM_E" should behave exactly the same as the "FM_S". It should furthermore be possible to send two-way traffic, i.e. it must be possible to transmit and receive alternately with one machine. The switching-over of the machine from "Transmit" to "Receive" is to be automatic and dependent on the incoming signals. As long as the text is coming in, the machine is to be switched to "Receive", but as soon as consecutive blank signals arrive, the machine is to cut out reception and be ready to transmit. The decision as to whether text or blank signals are being received can, however, only be made after the fifth signal, as the cutting-out and switching-over can only come into effect if all five signals are blanks. Therefore, the signals in the receiver, after decyphering, must once more be collected and triggered. This task is taken over by the auxiliary collector together with the distributor "SK_2".

C). Synchronisation.

On the synchronising switch being put over, the transmitter sends 6 complete teleprinter signals without current and one with current. This procedure is repeated periodically.

a). Coarse Indication (Fig. 3). The signal with current serves as a coarse indication. The receiver is synchronised with this signal during the starting period. The starting period lasts 1050 msec. This period is necessary in order to ensure that the starting switch is turned on for starting. Two glow-lamps serve as indicators and have to be extinguished by means of the phase regulator, which is effected by "blacking out" the whole signal by means of cams 1 and 2.

b). Fine indication (Fig. 4). The fine indication enables the phase to be accurately adjusted. For the purpose of measuring the phase, the falling side of the stop of the incoming signal is compared with the falling side of a signal produced in the receiver, which has been moved through 180 degrees. By altering the sides, voltage-peaks are produced which control two saw-tooth generators. A moving coil meter indicates the direct current components between the two generators and this is the measurement of the phase deviation between the transmitter and the receiver.

D.) Starting.

By switching on the "advance signal" switch, the stop signals cease to be transmitted. The complete signal of 115 msec is now only sent out every 1050 msec. After the advance signal lamp has been lit up three times, the starting switch is actuated in the transmitter and in the receiver. Actuating the switch is only a preliminary to starting. The actual start is effected by two parallel cams of 1050 and 150 msec duration.

E.) Drive (Fig. 5).

The following is used as the regulating principle for the synchronised drive: Periodic loading of a single armature transformer on its slip-rings by means of a thyratron switch. The thyratron switch is controlled by the quartz frequency of 83 $^1/_3$ Cs obtained by frequency division.

To synchronise the motor, the latter is overexcited on being switched on. The excitation declines slowly, thus causing the number of revolutions to rise slowly. After the nominal number of revolutions is reached, the modulator indicates a frequency of zero and the excitation then remains constant.

The modulator compares the frequency of 83 $^1/_3$ Cs derived from the quartz with the frequency derived from the motor. If both agree exactly, the value of the matched exciter current is maintained via the starting arrangement and the excitation remains constant.

IV. Technical Data.

1. The synchronising installation is designed for voltages of 110 - 250 volts, 50 cycles.

2. When working from 220 volt mains, mains voltage fluctuations in the range 170 - 250 volts are automatically smoothed out for the apparatus.

3. The telegraphy code can be arranged for 7 or $7\frac{1}{2}$. In one direction, therefore, output is about 500,000 letters per day; with four-channel working, therefore, it would thus be about 1,000,000 letters per day for both directions.

4. The encyphering apparatus is designed so as to be capable of being removed separately, so that it can be changed as occasion demands. For experimental purposes, the cypher drums (which are well known from normal teleprinter operatic from the cyphering attachment of Messrs. LORENZ of Mülhausen, were used. The firm itself has also made attempts to improve the cypher machine, but the experiments could not be completed owing to the war.

5. The accuracy of the quartz control is of the order of magnitude of 10^{-7}/sec. The synchronising apparatus can run for 10 to 12 hours without reciprocal phase comparison, without falling out of step during that time.

V. General facts in regard to the synchronising installation:

1. The synchronising installation can be used for two different types of work.

a) As an independent line, traffic passing only between one W/T station and another.

b) As part of a teleprinter network, when for instance, a W/T synchronised line is switched into a normal L/T teleprinter network. In this case, the synchronised line would be connected to the T/P exchange by means of the four-channel system.

2. The synchronising installation is to a large extent completely automatic and therefore requires only a very small staff of operators, 1 to 2 men sufficing.

3. As the cypher machines are running constantly in the synchronising installation, they transmit pure cypher during the times when no teleprinter signals are being sent. Peak periods or slack periods of traffic cannot therefore be recognised by studying the W/T traffic, as the traffic is camouflaged.

4. The synchronising installation permits the use of any modulation processes that may be desired for W/T transmission. The keying relay of the synchronising installation supplies double current.

VI. State of development.

As regards the development of "synchronisation", at the beginning of 1945 there was a complete link consisting of two stations equipped with the usual normal teleprinter cyphering attachment for experimental working. The link worked between the FEUERSTEIN laboratory at EBERMANNSTADT and the experimental post of Professor VIERLING at WENNEBOSTEL near HANOVER.

During conveyance from WENNEBOSTEL via PLANKEN/MAGDEBURG to here, a complete station (including a large number of constructional documents) was lost as the result of aerial attack on the arterial road near HERMSDORFER KREUZ, so that only one station is available at the moment.

After replacing the lost apparatus and a brief, final period of experimental working, which has not so far been carried out owing to lack of time, the development of "synchronisation" would be complete and it could then be turned over for possible manufacture.

The Problem:

The problem was to develop an apparatus for telephonic encypherment which could also be used for W/T. It is therefore essential, under all circumstances, that a constantly varying cypher is available.

Regarding the basic principles:

As we had had no previous experience that would help to solve this problem, we decided at first to evolve individual components from which we could build up an "uncrackable" apparatus. It then occurred to us that the suggestion put forward by H. DUDLEY of the BELL TELEPHONE LABORATORIES offered considerable prospects; this suggestion involved the splitting up of the speech into its individual characteristics, which are then transmitted by selected carriers. The speech is afterwards artificially reproduced in the receiver by controlling these characteristics. This apparatus would not, of course, provide absolute encypherment, but only scrambling. A so-called channel-scrambling, i.e. a periodic or permanent variation of the assignment of the individual carrier frequencies to the characteristics would also fail to produce a real encypherment. We planned to carry out a total encypherment of these characteristics by superimposing interference direct voltages similar to speech in each channel, compensating these interference voltages again in the receiver. Furthermore, the amplitude modulation of the individual speech channels was to be replaced by frequency modulation. It has not hitherto been possible, however, to test these two methods. To put them into execution would require a considerable time for development before they would be ready for operational use and plans were therefore made to obtain an adequate cypher by combining artificial speech with another method, that of "three-fold wobbulating", which is described in another section. In this connection, the cypher period is derived from a telegraphic cypher which is already available.

Description of the construction:

1) Transmitter. The circuit can be seen in Fig. 6. The speech fed to the transmitter is split into 8 frequency bands of 180 - 3060 Cs by the band-filter (Fig. 7). The 8 partial bands thus obtained are amplified to determine their power content and rectified (Fig. 8); the direct potential thus obtained is a measure of the speech power contained in each frequency band. The 8 carriers are next amplitude modulated by means of these 8 direct voltages (after they have been filtered through low-pass filters of 30 Cs each) and passed together to the line. The available frequency band could easily be restricted to 300 - 2400 Cs by choosing suitable carrier frequencies, but this would entail increased expenditure in building the carrier filters. For the sake of completeness, it should be mentioned that we have constructed a laboratory model with 15 speech channels, but found out by experiment that the quality of the speech suffers only very slightly when only 8 channels are used, if the frequency range used is the same.

The transmission of a characteristic for the fundamental pitch and the periodic pitch fluctuations of each speaker are essential for the faithful reproduction of the speech in the receiver. During development, the measurement of this fundamental tone caused us tremendous difficulties. The amplitudes of the fundamental tone are always subject to great fluctuations and, in some cases, are just non-existent, so that they have to be produced artificially from their overtones by frequency intermodulation. The principle of the

The speech passes through a 180 - 660 Cs band filter and a logarithmic amplifier to the frequency intermodulator, which produces the fundamental tone artificially by modulating several overtones together. The fundamental tone thus produced is taken through a second band-pass and a further amplifier to a multi-vibrator, which transforms the sinusoidal alternating voltages put into it into rectangular voltages of constant amplitude. This rectangular voltage is differentiated in the impulse stage; the peaks thus obtained, the number of which is proportional to the frequency of the fundamental tone, are rectified and used via a 30 Cs low-pass for modulating two carrier frequencies. At first sight it is not at all apparent why the modulation of two carriers should be necessary, but this is merely a safety measure in order to ensure fundamental tone control by the receiver side in the event of the possible failure of a carrier.

An additional difficulty is the later inclusion of a device for switching over the carrier assignment to the individual characteristics.

Receiver (Fig. 11): The 10 carrier frequencies coming from the line are separated by a corresponding number of carrier filters (Fig. 12) and taken to the appropriate speech or control channels. In the speech channels, the characteristics produced at the transmitter are recovered by rectification and used for modulation with the appropriate harmonics from the impulse or noise generator. The impulse generator (Fig. 13) serves to produce the harmonic frequencies present in the speech, whilst the noise generator (Fig. 14) reproduces the unvoiced, unharmonic sounds of speech. The carriers assigned to the control channels are likewise rectified and used for controlling the fundamental pitch of the harmonic generator (impulse generator). If no direct voltage is present in these channels, the changeover switch (Fig. 15) connects the noise generator to the speech channels, whilst on the appearance of a direct voltage this connection is cut off and the harmonic generator switched in instead. The 8 frequencies occurring behind the modulators in the speech channels are taken through filters and switched in together and now form the artificially produced speech. For the practical working of the apparatus, it is necessary for both transmitter and receiver to be provided with a call-shunting device for carrying the call impulse. In addition, there is an indicating amplifier behind the input amplifier of both the transmitter and the receiver in order to be able to control the requisite level and set it.

State of the work:

The synthetic speech production installation is almost complete as regards its metallic structure. Only the melody transmitter, the impulse generator, the noise generator, the changeover switch, the mains unit and the input and output amplifiers are lacking. All constructional data have been determined, however, for the components still outstanding.

Three-fold wobbling.

As already mentioned in the report on artificial speech, in obtaining an adequate cypher, another process was developed consisting of the combination of multi-wobbling with ring inversion and designated as three-fold wobbling (WTV). The basic process in the transmitter (Fig. 16) is as follows: The speech band of 300-2400 cycles is displaced in frequency in two parallel modulators (Fig. 17) on the input side by a suitable choice of carrier frequencies, so that after filtering out the lower side-bands there are produced two adjacent inverted frequency bands possessing together twice the speech-band breadth (4200 cycles). This new band of 4200 cycles breadth is impelled to and fro in front of a band-filter of 2100 Cs breadth (Fig. 18) by a modulator with continually varying carrier frequency (wobble carrier) in such a way that a constantly changing portion is filtered out of the 4200 cycle band in which, however, all the frequencies originally present are still present but in a constantly changing place. After this first wobbling, the new band of 2100 Cs breadth is split by filters into two half-bands each of 1050 cycles, each of which is separately and similarly inverted and wobbled as in the first stage of the total band. This division into two adjacent bands each of 1050 cycles frequency band breadth, both of which are wobbled with dissimilar wobble strokes, is to destroy the speech texture. The two new half-bands obtained after passing through the second stage are again combined to form a total band of 2100 cycles breadth, which in the third stage is once again ring-inverted and wobbled. After passing through this stage, the band which is in the range of 13500 to 15600 cycles as a result of repeated modulation, is reduced by further modulation to the range of 300 to 2400 cycles and passed to the line. The fixed carrier frequencies are produced in generators (Fig. 19) working on the principle of the Transitron circuit and having an adequate frequency constancy. The wobble frequencies are produced in reaction generators, whose frequency control for the final apparatus is derived from an already available telegraph code and is described separately.

In the receiver (Fig. 20), the same process as in the transmitter takes place in exactly the reverse order. A detailed description of the individual frequency transpositions is therefore superfluous.

In order to reproduce the speech faithfully in the receiver, it is unconditionally necessary to synchronise the four different wobble frequencies (which are constantly altering) in the transmitter and in the receiver. The laboratory experiments so far carried out were at first undertaken without synchronising equipment. For the sake of simplicity, the respective wobble frequencies for the transmitter and receiver were taken from the same wobble generator.

Owing to the large number of modulations occurring, the highest degree of performance had to be demanded of the filters employed in order to avoid all undesirable modulation products. The occurrence of gaps in the total frequency band of the speech, which would appreciably reduce the quality of the speech, was avoided by a special artificial circuit for steepening the sides.

An earlier laboratory three-fold wobbling model, built by us with filters that did not satisfy these high demands, failed to produce speech of adequate quality owing to the frequency gaps on leaving the receiver.

State of the work.

The following are available: Filters, amplifiers, modulators, generators and four mechanical wobble generators for transmitter and receiver, constructed for use in the laboratory.

For the final design of the "uncrackable" apparatus, it is intended to use the artificial speech transmitter as a preliminary to the three-fold wobbling. At the input of the WTV transmitter there will not then be pure speech, as the 10 carriers from the artificial speech apparatus will be fed in here. At the WTV receiver output, then, these carriers will be taken to the artificial speech receiver, which transforms these characteristics into synthetic speech.

Synchronising installation for producing the wobble-frequencies

for three-fold wobbling.

For speech encypherment with "WTV" (=wobbulated total encyphering), four wobble frequencies must be led synchronously and in equal phase to the wobble apparatus at the transmitting and receiving stations. The periodic course of these frequencies must differ from each other as much as possible and each wobble frequency must pass through its envisaged frequency range in the most discontinuous way possible. This task is solved in the following way (Fig. 5):

1.) The synchronising and phase equalisation at the transmitting and receiving stations is effected by quartz-crystal controlled synchronising, as developed in our laboratory for telegraphic encypherment.

2.) The wobble frequencies are produced by electronic generators (each of whose oscillatory circuits includes a variable condenser), which are rotated from the synchronising apparatus via special intermediate gearing and thus bring about a variation of the wobble frequency within the range dictated by the capacitance variation.

3.) By altering the gearing ratio between the synchronising apparatus and the variable condenser, the intermediate gearing permits the periodic course of the capacitance variation to be altered - depending upon the cypher signals that are transmitted by the telegraphic cypher contained in the synchronising apparatus.

4.) The different courses of the four wobble frequencies used are effected by the five impulses of which each cypher signal consists being reduced via a collector and distributor to four different control impulses for the intermediate gearing.

Description:

Re 1.): The control apparatus and the cypher from the telegraphic synchronising apparatus can be used without alteration for speech encypherment. The cypher-box with its drive is simpler, however, as the cams required for telegraphy can be dispensed with. It is recommended that it be combined, from the point of view of construction, with the intermediate gears and the collector-distributor. Starting, on commencing working, and the control of the phase position are, however, effected in a manner different from that used in telegraphy, as the cypher signals are no longer transmitted to the repeating station. Synchronising frequencies are transmitted via special carrier frequency channels and

Re 2.): The usual electronic generators with reaction are employed for generating the wobble frequencies.

Re 3.): The task of the intermediate gearing is to derive variable numbers of revolutions from a constant number of revolutions of a high degree of constancy in such a way that the variations are clearly defined according to size and phase and apply to the transmitting and receiving sides with the degree of accuracy imparted by the synchronising gear.

The working principle is as follows: The shaft coming from the synchronising gear carries a system of eccentric discs which move impulse rods to and fro, these impulse rods being constructed in the form of toothed rods. Above the toothed rods are arranged gear wheels with which the toothed rods can engage, in such a way that in each case only one toothed rod turns the gear wheel, and the latter is always turned in the same direction. The eccentric discs have different strokes so that, according to the identity of the toothed rod engaged, the gear wheel shaft describes a different angle of rotation in one unit of time. To the gear wheel shaft is coupled the variable condenser of the frequency generator, which therefore executes a non-continuous rotary movement. Four different angular velocities are provided, so the picture presented by the following diagram provides an example of the periodic course of a wobble frequency:

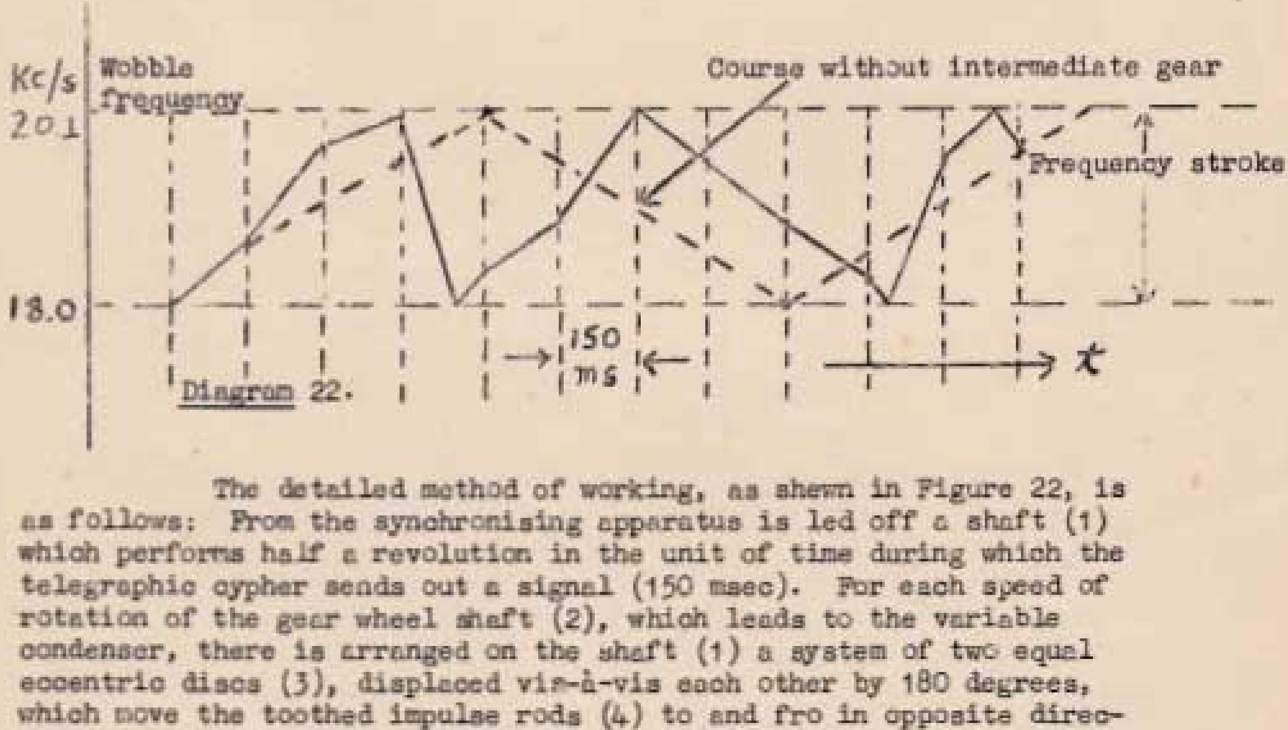

Diagram 22.

The detailed method of working, as shewn in Figure 22, is as follows: From the synchronising apparatus is led off a shaft (1) which performs half a revolution in the unit of time during which the telegraphic cypher sends out a signal (150 msec). For each speed of rotation of the gear wheel shaft (2), which leads to the variable condenser, there is arranged on the shaft (1) a system of two equal eccentric discs (3), displaced vis-à-vis each other by 180 degrees, which move the toothed impulse rods (4) to and fro in opposite directions against the recovery springs. In the left-hand position of rest, a brief but complete immobilisation of the toothed rod is effected by the special shape of the eccentric discs (3). During this time and depending upon the cypher signal, the magnet (6) is excited and, by means of the two-armed lever (7), lifts the impulse rod (4) so that the latter's toothing engages the gear wheel (8) on the shaft (2). As soon as the advance movement commences, the gear wheel (8) is actuated too. Simultaneously, the pin (9) penetrates the upper groove of the slide bar (10) and thereby holds the toothed rod (4) engaged with the gear wheel (8). The magnet (6) is now able to release again. As soon as the advance movement ends, the toothed rod (4) falls into the lower groove via the right-hand end of the slide bar and thus becomes disengaged from the gear wheel, which now stops.

This moment is simultaneously the beginning of the brief immobilisation of the opposite-running toothed rods. A fresh engagement can come about by lifting one of the opposite-toothed rods, whereupon the rotary motion of the gear wheel will continue, according to the impulse imparted, at the same or at another angular velocity. The toothed rod which has just been engaged is simultaneously taken back to the lower groove of the slide bar, during which period no engagement with the gear wheel will be possible. When the opposite-running toothed rod is lifted, in order to prevent the first rod from being raised as well, the clearance (11) is provided on the toothed rod and this clearance receives the slide bar roller on the lever (7). For the pairs of discs and toothed rods assigned to each angular velocity, only a common lifting magnet (6) with lever (7) is required. On the shaft (1) there are four similar double systems, whose advances are all different, but must in each case be a whole multiple of the same indentation for all the toothed rods, so that a smooth engagement occurs in each case. After each half-rotation of the shaft (1), only one of the four magnets is excited, according to how the collector-distributor imparts the impulse. Correct insertion is ensured by a contact controlled by a cam on shaft (1).

Re 4.): The cypher continuously transmits signals which are equal as the result of the synchronising at the transmitting and receiving stations and which consist of five impulses in accordance with the 5-unit alphabet. In order to obtain from one signal four angular velocities differing from each other for controlling the four wobble frequencies, each of the four first impulses is combined with the fifth impulse. Thus, four different combinations are produced in each case:

1) +-   3) -+
2) ++   4) --

To each of the four combinations is assigned a magnet of the respective intermediate gearing, so that, for instance, from the signal - - + - + the following impulses are produced:

For	the	first	wobble frequency,	impulse	1	with	impulse	5	- +	gives velocity	3)
"	"	second	"	"	2	"	"	5	- +	" "	3)
"	"	third	"	"	3	"	"	5	+ +	" "	2)
"	"	fourth	"	"	4	"	"	5	- +	" "	3).

These combinations are obtained in the collector-distributor by means of relays, e.g. according to the circuit shewn in Fig. 23. The triggering of the signal is effected by cam switches synchronously driven by the synchronising apparatus.

Scrambling apparatus (small BAUSTEIN).

In order to make it difficult for unauthorised persons to overhear conversations, there was available in Germany an apparatus under the name of "Inverter" which reversed the natural speech frequencies, i.e. transformed high into low frequencies and low into high. Since the scrambling effect of this device was almost insignificant after a short period of becoming accustomed to it, it had to be improved by an extended method.

The results of fairly long experiments yielded the following experiences: Every speech sound has, in addition to characteristic frequencies. a dynamic peculiar to it and an oscillating process peculiar to it; in many cases, especially in regard to monosyllabic words, the presence of the dynamic and the oscillating process is quite sufficient to enable the word to be recognised. This recognition is made particularly easy when, as the result of a fixed frequency change, the characteristic frequencies are moved into another, but still common, range.

Taking into consideration the fact that the cost had to be as low as possible, the following extended method was envisaged for the construction of a scrambling device:

1.) Restricting the speech band to be transmitted to the frequencies of 200 - 1300 cycles.

2.) The addition of a noise of equally great level and equal frequency breadth containing, if possible, all the speech frequencies.

3.) The constant mixing of the speech and noise bands in adjacent frequencies by switching over, with the speech band inverted in addition.

4.) Influencing the switching over of the speech dynamic by accelerating the switching over frequency.

5.) The suppression of noise during pauses in speech.

6.) An addition, to be provided later if necessary, which delays, from the point of view of time, the acceleration referred to in 4.) in order to obtain an effect resembling an echo.

In order to change back at the receiving end the switching over that has been carried out, the controlling of the switching-over is passed currently to that end in the frequency band 300 - 400 cycles, which is purposely kept free of speech frequencies for the purpose. As, in the case of two-wire operation, two non-synchronised controls are present on the line, even when a third receiver suitable for this scrambling process is switched in, eavesdropping is as a rule impossible because no <u>unambiguous</u> control is present.

To test this apparatus by working it over fairly long lines, two opposite stations are being erected, in a form approaching the final constructional design, in parallel with a purely laboratory experimental construction. The construction of this apparatus is still in progress.

The function of this apparatus is briefly explained below on the basis of the attached "flow of current" diagram:

The speech voltage coming from the telephone is amplified by a forked carrier in the input amplifier of the transmitter.

This amplified voltage is then

a) Taken via a potentiometer of a suitable size via a low-pass to the two speech switches, and

b) After rectification, is used for controlling the noise generator and for influencing the switching frequency (later, if necessary, via the running time component).

The noise generator feeds the two noise switches which are in parallel with the two speech switches.

With the object of moving to the desired frequency bands, the speech frequencies are converted, in accordance with the switches in the ring modulators, with the aid of the two carrier frequencies of 1700 and 2700 cycles. It is not necessary to lead the noise via modulators, as this frequency band is produced from the start up to the breadth of 2500 cycles necessary for using the line.

For filtering out the desired modulation products or frequency bands, speech and noise are led via the four parallel filters inserted at the output

1) Low-pass up to 1500 cycles 2) Low-pass up to 2500 cycles

3) High-pass of 1600 cycles and over 4) Low-pass up to 1300 cycles.

The switches of the filters 1) and 3) or 2) and 4) are always simultaneously open or closed.

At the output of the filters is an amplifier and after that a high-pass, which reliably filters out all the frequencies below 400 cycles.

The frequency mixture of 400 - 2500 cycles is then passed to the line via a forked carrier.

The control voltage for switching over is produced from the frequencies of 340 and 343 cycles passed over a ring modulator and filtered out through a low-pass. A two-stage amplifier that follows brings up the necessary switching power.

Of the two generators, the 343 cycle generator is altered, by the influence of the speech in its frequency, up to 346 cycles. The 340 cycle generator remains constant and is used as the carrier for the controlling transmission. For this purpose it is modulated with the control frequency of 3 - 6 cycles tapped behind the first amplifier stage. The control frequency, together with the speech, is passed to the line via a forked carrier and a band-pass of 300 - 380 cycles filter breadth.

Of the speech, the noise and the incoming control frequency which arrive in the line, all are led via the line forked-carrier and the level-regulator to the two parallel band-passes with a filter width of 400 - 1500 cycles and 1400 - 2500 cycles

In the two ring modulators, the respective frequencies, and particularly the speech frequency, are put back into the original frequency band with the aid of the two carriers of 1700 and 2700 cycles. In order that only the two speech frequencies should be audible in the receiver, the succeeding switches are only closed alternately, synchronously with the transmitter and with the aid of the control frequency transmitted, when the incoming frequency band contains the appropriate speech band.

The speech is then taken via an amplifier, and the subsequent band-pass with a filter range of 200 - 1300 cycles, and via a forked carrier to the telephone.

The control frequency is branched off in parallel with the line forked-carrier and taken, via the band-pass with the filter range of 300 - 380 cycles to the control-note forked-carrier and a level regulator, to an amplifier. After demodulation, the control voltage of 3 - 6 cycles is taken to the switches via a power amplifier.

Individual circuit diagrams are appended of the circuit elements used, including the switch, the noise generator and the device for producing the control frequency.

1) The switch makes use of the property possessed by Cu_2O cells, which have a resistance dependent upon the direction of the current. According to the polarity of the control voltage, the cells, which are arranged in a longitudinal circuit, either let the current through or block it. Two means are used to suppress the residual voltage in the blocked condition:

a) A short-circuit via the primary winding of the output carrier through Cu_2O cells connected in the opposite way,

b) A bridge connection consisting of a capacity and a resistance, for taking an equally great and oppositely directed voltage to the output transformer.

2) The noise generator makes use of the occurrence of noise in the anode circuit by using superregeneration. A high frequency oscillatory circuit in the triode portion of the double valve ECH 11 is firmly coupled with a low frequency oscillatory circuit in the hexode portion by means of the connection between the triode grid and the hexode grid inside the valve. The oscillation of the low frequency portion lies far above the highest frequencies present and used in the noise. Further support for the superregeneration is afforded by the inductance of the input transformer of the switch, which is present in both anode circuits. The closing and opening of the valve is effected by an alteration in the grid voltage through the rectified speech frequencies.

3) The double valve EDD 11 is used to produce the control voltage with a frequency of 3 - 6 cycles required for the circuit. The connections of this double valve can be seen from the appended individual circuit diagram "Control voltage production". The two separate generators of 340 and 343-346 cycles have the familiar 3-point circuit; only the dual use of the 340 cycle generator as the carrier frequency for the 3 - 6 cycles and as the carrier for transmitting the control frequency are shewn in detail, together with the influencing of the frequency of 343 cycles by the displacement of the grid working point of the valve.

Frequency plan:

Speech	Noise
Output valve	
200 - 1300 cycles	200 - 2500 cycles
To the four output filters	
After modulation with 1700 cycles	----
1500 - 400 cycles	1600 - (2500) cycles
After modulation with 2700 cycles	----
2500 - 1400 cycles	200 - 1300 cycles
On the line	

400 - 2500 cycles, plus the control frequency 340 ± 3 - 6 cycles.